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APE OR MAN?

AN INCOMPLETE CHAPTER OF HUMAN ANCESTRY FROM SOUTH AFRICA[1]

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Psychology can no doubt account for the almost morbid interest modern man displays in his ancestors and their humbler relatives. The deader they are, the more fascination they seem to hold for him. Nor is he deterred by finding that some were hanged for sheep-stealing, or eaten for cannibalism. Mere reference to a "missing link" is good for a 96-point news headline at any time.

The particular group of near-relatives whom I wish to present to you this evening are some whose remains came to light recently in South Africa. The finds were made at sites I visited some months ago, thanks to invitations from the Archaeological Survey of South Africa, the University of the Witwatersrand at Johannesburg, the Bernard Price Foundation, and the University of California's African Expedition under Dr. Charles L. Camp, of which I was privileged to be a member.[2] While the fossil finds themselves have received wide notice in the scientific press, much less has been said about their field-setting and the broader problems they involve. These range beyond the confines of the anatomist's laboratory, and call for a concerted attack by geologist, stratigrapher, physiographer, climatologist, anthropologist and paleontologist alike. The critical questions still await precise answers. Perhaps this only makes an interim report of progress the more appropriate at this time.

South Africa, the sub-continent from the Zambesi to the Cape, is a large place—almost half the size of the continental United States. One may think of it as a shield-shaped platform of older deformed rocks, worn down by weather and water to a surface of low relief, and then buried by a thick cover of flat-lying younger layers—mainly sand and silt, glacial debris, and lava. These younger strata—the earliest dating back to the days of the swamp forests which became the Coal Measures of Pennsylvania—take their name from the barren Karroo plateau-land which they build. The distorted older formations on which they rest range from early Pre-Cambrian to Mississippian in age. The whole platform, originally considerably larger than it is today, was buckled and broken down along its southern and south-eastern margin, and faintly warped in the interior. But otherwise it has stood remarkably stable over a span of later geological time measurable in many tens of millions of years—long enough for much of the flat Karroo overlay to be stripped off down to the older foundations, and for the heart of the region to be blanketed with the sand of the Kalahari desert.

[1]Presidential address delivered before the Ohio Academy of Science, at Denison University, Granville, Ohio, April 22, 1949.

[2]I am under personal debt to my Johannesburg host, Dr. Raymond Dart, to the late Dr. Alex DuToit, dean of South African geologists, to Dr. Sidney Haughton, Director of the Geological Survey, to Prof. C. van Riet Lowe, Director of the Archaeological Survey, Prof. J. C. van der Horst and other members of the Bernard Price Foundation, as well as to scientists who guided me in the field—especially Dr. Robert Broom, Dr. B. M. Malan, Dr. H. B. Cooke, and my colleague, Dr. Frank Peabody.

The coast, like that of Europe and North America, preserves in places the etch-marks of wave action and traces of marine veneer which record the fall and rise of sea-level—due either to the refrigeration and melting of the Great Ice Age, or to the slow faint heavings of the Earth's crust. In the extreme south the Cretaceous sea had pushed two long arms inland between flanking ranges, while a brief still earlier incursion of ocean waters formed the shallow Bokkeveld Sea (Lower Devonian). But with these exceptions, virtually the entire area has stood above sea-level since the dawn of the Paleozoic Era.

Thus South Africa has been uninterruptedly "continental" since before forests first appeared on the earth, when primitive fishes were the most advanced form of life, indeed, if we exclude the area flooded by the Bokkeveld Sea, since the days when backbones were still inventions of the future, and the master race on the

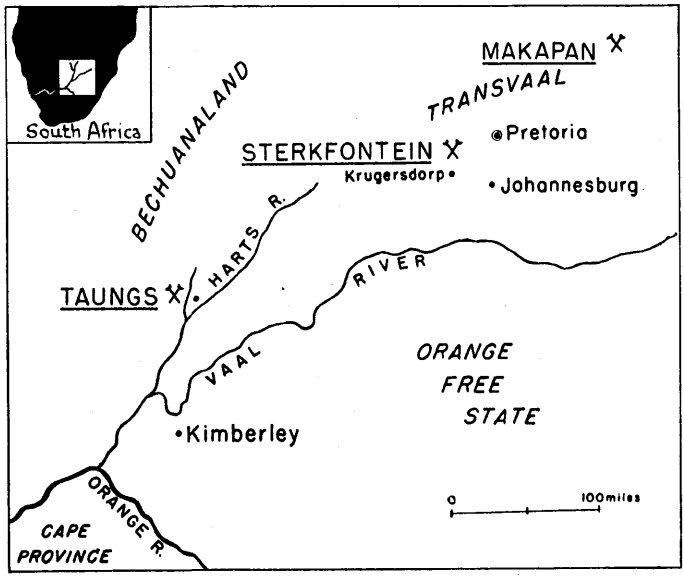


FIG. 1. Location of Australopithecine sites.

planet were the sea-faring molluscs and their humbler relatives. Hence the region offers a chance to find new paragraphs in the fragmental record of what must have been a continuous evolution of land-inhabiting creatures.

A century ago (1856) A. G. Bain first astonished the geological world by finding superb reptile remains in the Karroo strata (1). Others followed in his footsteps. To Dr. Robert Broom goes credit for awakening the government to the scientific importance of these national treasures in the Karroo. It may be interjected in passing that Dr. Charles Camp of the University of California, himself an authority on reptilian fossils, was already familiar with the region, and at the invitation of General Smuts made it a primary objective of his expedition in 1947–1948.

The Karroo reptiles had their heyday, and in due time gave place to four-footed mammals, and these in turn to the rarer two-footed ones of which I speak tonight. The reason for their rarity is obvious. The present era is one of denudation, and when a land surface is being worn down at an average rate of about a foot in 1500 years (2), such perishable objects as skeletons are soon destroyed. Indeed, only when they happen to be deeply entombed, or lodged in a protecting cave or fissure below the general surface of erosion, are they likely to be preserved. Fortunately, in places, the stripping away of the Karroo strata exposed older beds of limestones which, like those of Virginia or the Mammoth

Cave district, dissolve away, leaving caverns that offer a night's shelter to man and beast.

Much of this stripping was the work of the Orange River and its tributaries, of which the most important is the Vaal. This draws its headwaters from the Eastern Transvaal, so that rain water falling within 160 miles of the Indian Ocean may travel 1000 miles across the width of the continent before entering the Atlantic. For 300 miles the Vaal forms the boundary between Orange Free State and the Transvaal, passing within 40 miles of Johannesburg and Krugersdorp before striking southwest to join the Orange River (Fig. 1). Above this confluence, when abreast of Kimberley, it is joined by the Harts River which comes in from the north along the edge of Bechuanaland. A branch of this stream, the Dry Harts, flows between the village of Taungs and the edge of the Kaap plateau, an escarpment of Transvaal Dolomite (late pre-Cambrian) in which a quarry was opened by the Northern Lime Company during the first world war.

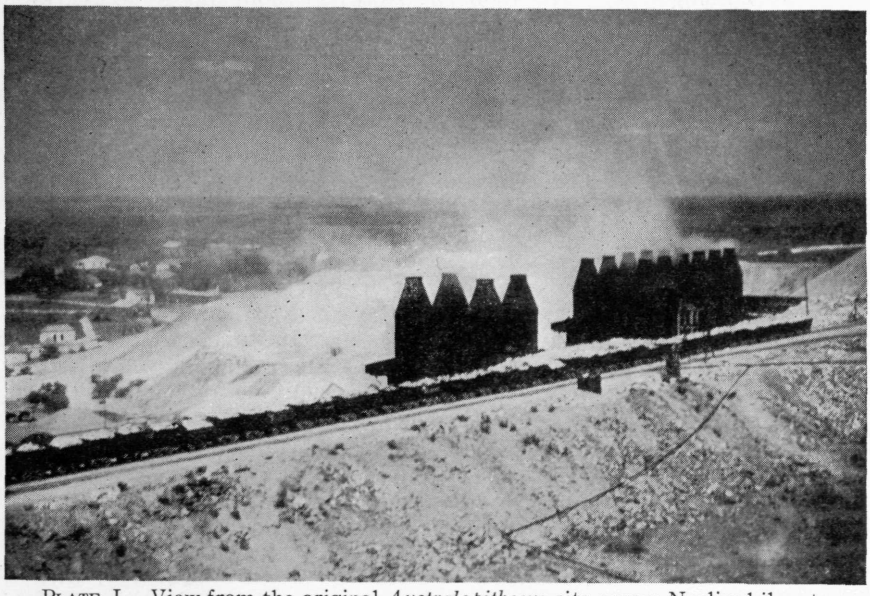


PLATE I. View from the original *Australopithecus* site across Norlim kilms to Dry Harts valley.

From this Norlim quarry in 1924 came a fossil skull, of which its scientific foster-parent, Dr. Raymond Dart, wrote: "The specimen is of importance because it exhibits an extinct race of apes intermediate between living anthropoids and man" (3). The head was that of a six-year old, not of a full grown adult. But Dart drew attention to the human, rather than ape-like, character of its jaw, teeth, eye-sockets and skull contours. Despite these features, however, he was not ready to grant the creature full human status, considering it rather a pre-human type. Other eminent anthropologists were less kind, stressing its sub-human aspects and dismissing "Dart's Baby" as more akin to the gorilla or chimpanzee than to Man. So for a decade *Australopithecus africanus* Dart—the "southern anthropoid from Africa"—had to bide his time on the shelf.

In 1886 gold had been struck on the Witwatersrand—we would have named it the Clearwater Reef—and a string of settlements sprang up overnight on either side of Johannesburg along the outcrop of ore-bearing conglomerate which was to yield 10 billion dollars of the precious metal. The following year, one of these mining camps in the West Rand district, 25 miles from Johannesburg, was named after the president, Paul Kruger. Today Krugersdorp is a thriving town with

sixty miles of tree-lined streets, in the heart of a district which still retains the original names and curiously shaped boundary lines of farmlands granted to the first Dutch settlers. Farther south these farm plats are often circular, being the largest area the first owner could ride round and stake out with stone cairns between dawn and sunset.

Over the lunch table at Pretoria, a leading lawyer told me that as a boy, when his family still owned the farms of Swartkrans and Kromdraai, six miles from Krugersdorp, he used to play bowls on the attic floor with a "stone skull," one of several that had been picked up in the fields. The soil, however, was poor and the Swartkrans farmlands were better known for the Sterkfontein caves in outcrops of the limestone which was worked for the kilns. For half a century, fossil bones of antelope, horses, monkeys, baboons, porcupines, and rats have been picked from the rock debris in the caves. In 1935 the enterprising author of a tourist guide to the district even advised visitors to "Come to Sterkfontein and find the missing link!" In 1936 Dr. Robert Broom did go to Sterkfontein and found the broken skull of *Australopithecus transvaalensis* (4). Later study led him to establish it as a new genus, *Plesianthropus*, though still a member of the same family of Australopithecinae as Dart's original find.

In 1938 another australopithecine, *Paranthropus robustus*, was found two miles away at Kromdraai, thanks to a fossil-hunting schoolboy, who had been carrying round in his trousers pocket four precious teeth—"the most wonderful ever seen in history"—on which Broom at once pounced. In his book on "the South African Fossil Ape-men," Dr. Broom gives a racy account of the events which led up to this and the other finds in the Sterkfontein area, including the way in which he persuaded the school headmaster, in return for a lecture on the importance of caves, to let the boys out early enough for Gert Terbranche, the lad in question, to take him back to the spot before dusk. Since then, more has come from both Kromdraai and Sterkfontein (5). In June of the season I was there, a remarkably human-looking pelvis came to light (6), and Dr. Broom now has fossil parts representing more than a dozen distinct individuals, some betokened only by their share of the gross of teeth that have been collected. In April, 1948, twenty-six pits were excavated by the University of California Expedition at Bolts Farm, a mile from Sterkfontein. From two of them australopithecine leg bones were recovered (7). Finally in December, 1948, Dr. Broom reported the finding at Sterkfontein of the teeth and massive lower jaw of "Swartkrans Man" (8), apparently a related creature, but of distinctly heavier build.

Appropriately named *Paranthropus crassidens* ("coarse-toothed"), with teeth 50 per cent larger than *P. robustus*, the creature resembles in this respect the so-called giant types found by von Koenigswald in Java and known also from South China (9). Thanks to enviable public relations in the weekly press, Swartkrans Man has earned the reputation of a giant. Actually there is no evidence of great stature. The amount of his remains thus far recovered is distinctly limited,—limited in fact to four teeth, firmly embedded in a broken piece of his jaw not over three inches in length. This may suffice to let Dr. Broom's almost uncanny intuition restore the head (10). But it is a trifle risky to let fancy reconstruct an entire animal on the basis of its out-size dentition, mostly missing. The story is told of three agents for competing hair-restorers. The first dropped a bottle on his doorstep in the dark, and awoke next day to find a luxuriant fully grown door-mat. The second had a tabby which failed to give right-of-way to the lawn-mower, and was converted by caudectomy into a Manx cat, a mishap quickly remedied by the use of his magic hair-restorer. The discarded tail was thrown over the hedge. "Oh," said the third man, who lived next door, "I found that tail on the grass, and tried some of our famous restorer. Next morning we had a new cat." Even if reconstructions of Swartkrans Man prove later to be more accurate than the restored feline, it remains true that we had very little of him to start with.

Meanwhile field work had been progressing in Makapansgat valley, 150 miles to the north. A limestone cave had long been famous as the last holdout of the fierce native chief Makapan, whose marauding tribe had attacked Dutch settlers and killed their leader Potgieter. In revenge, the Dutch, after fierce fighting, drove the natives into the cave, filled the entry with a wall of stones and brushwood, set fire to the latter, and virtually exterminated the warriors within. A nearby cave showed signs of earlier occupation, and the Bernard Price Foundation provided funds for a meticulously careful excavation which, in the interval between my first and second visits, yielded Early Paleolithic implements. In the report which I was asked to make on the prospects of further success, it needed no great acumen to confirm the well-founded belief of the scientists of the Archaeological Survey directing the work that here, if anywhere, actual fossil remains of the makers of those stone tools should be found *in situ*. Still, it was satisfying to learn that two weeks later a jaw of Neanderthal type was blasted out of the travertine. I added the hope that excavating would also be resumed in a dis-

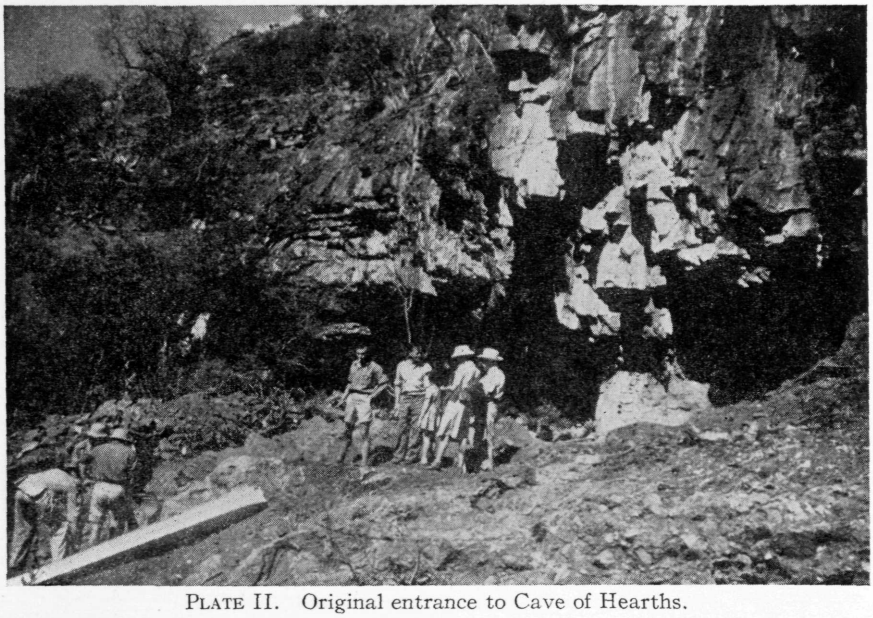


PLATE II. Original entrance to Cave of Hearths.

tinctly older cave deposit, at the limeworks a mile farther down the valley, where Professor Dart and his students had previously found fossil baboon skulls of a species associated with Australopithecines in the southern localities. Within a matter of days (September, 1947) Dart reported the finding of an adult australopith occipital bone (11), followed in July, 1948, by an infantile right parietal and an adolescent jaw, and finally last October by a right maxilla and part of the face of a female adult. Australopithecine remains have thus been recovered from dolomite caves in three widely separated localities—Taungs, Sterkfontein and vicinity, and Makapansgat—and further field work can hardly avoid uncovering more.

In the growth of scientific knowledge, the newer finds are often unkindly disconcerting. Where only a few data or single specimens exist, an easy explanation may fit all the known facts. Incomplete knowledge suggests a spurious simplicity. But newer discoveries refuse to fit the theory, and the first hypothesis has to be recast. Some of the certainties of the physics and chemistry of fifty years ago have been placed in the discard by a fissionable atom. For years French

and German anthropologists denied human status to Piltdown Man, if only on the ground that his skull was so thick—a pardonable lapse, perhaps, in view of the fact that he lived in England. But when Peking Man appeared in a North China cave, and proved the owner, not only of an equally thick cranium, but of stone implements and a dead fire on the hearth as well, the status of Eoanthropus had to be reconsidered. It has been so also with *Australopithecus africanus* Dart.

No one questions the claim of the Australopithecinae to accredited membership in the exalted Anthropoid Suborder of Primates to which both men and apes belong. There is more hesitation about accepting them into the family of the Hominidae, which includes our noble selves, *Homo, sapiens* and otherwise, *Sinanthropus* from Peking, *Pithecanthropus* of Java, and *Eoanthropus* from Piltdown. The first point of debate is how many anatomical quality points they had amassed towards graduation into true human status with all rights and privileges appertaining thereto—reading, writing, arithmetic, cannibalism, and atomic destruction. The second question is how close they stood to the ancestral stock from which modern man is descended.

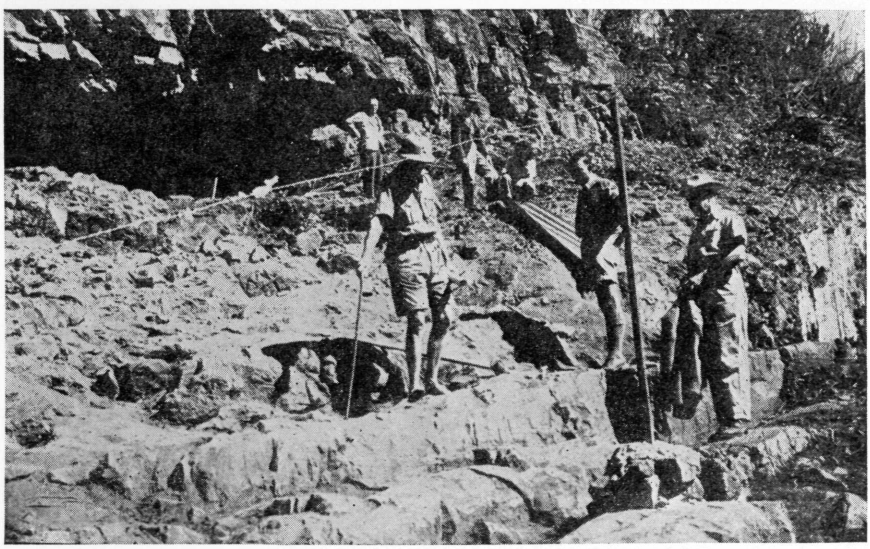


PLATE III. Excavation in progress at entrance to Cave of Hearths.

In any attempt to compare the mental ratings or I.Q.'s of the various primates, the volume and shape of the brain are often useful indicators. Account has to be taken, of course, of the body size, age, and sex of the individual, of the relative development of the different brain sectors, and of the extent and complexity of the convolutions which increase the brain surface without adding to its bulk. Average cranial capacities for the chimpanzee and gorilla are 400 and 480 cc. respectively, with possible extremes of 20 per cent in either direction (Fig. 2). In comparison, *Pithecanthropus* of Java is credited with from 750 to 900 cc. On this basis of skull fragments of 15 individuals, *Sinanthropus* is allowed 915–1225 cc. (average 1040), while *Homo*, ancient and modern, hovers around 1500 cc. but may extend as much as 30 per cent in either direction. For, while the oft-cited Dean Swift had a headpiece of over 2000 cc. and a modern Hottentot in Capetown had one of the same size, Anatole France did very creditable thinking with only 1100, while the great diplomat Leon Gambetta saved France with even less.

Thus while the hominid types range from over 2,000 cc. down to 750, there has existed an unfilled gap between the smallest brained humans and the highest living apes with 520 cc. It is precisely into this "No Man's Land" that the South

African types fall. The two *Plesianthropus* skulls held brains of 435 and 560 respectively, as against 650 for *Paranthropus*. The *Australopithecus* six-year old had a 520 cc. skull, which in view of his premature death is consistent with an adult brain of 700 cc. Of course we know neither the range of variation within each species, nor whether these particular samples were of average brain size for their types. Schepers points out that if the *Paranthropus* specimen was of average cranial capacity, mere normal variation within the species might well involve a range of from 490 to 815 cc. Thus the brains of the australopithecines span the gap between genuine apes and real men. On the basis of skull capacity alone, then, their status as fully human remains a moot point.

On the second issue, it is clear that no living or recent ape can be the close relative of anything but another ape. But going back a million years, the forebears of today's apes and men were less advanced, and perhaps a little closer to each other, as they were nearer to the common ancestor of both lines of descent. Possible closeness to human lineage is therefore directly related to other questions—How long is it since the australopithecines were alive? Did they all live at about

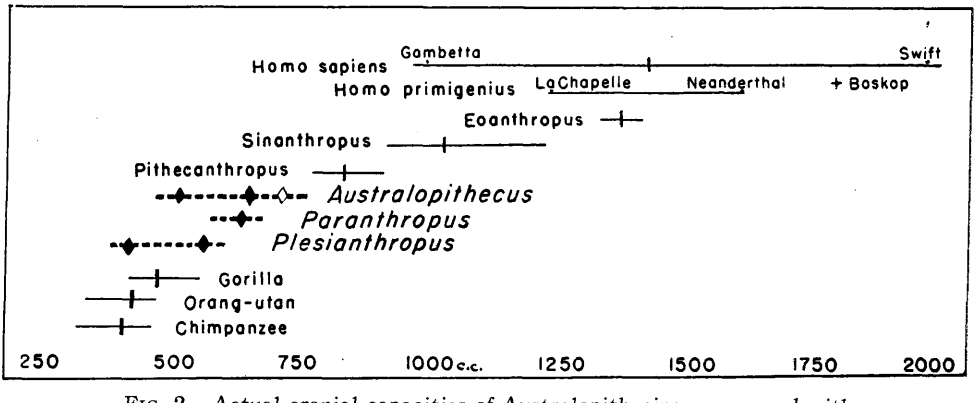


FIG. 2. Actual cranial capacities of Australopithecinae compared with averages and ranges for other primates.

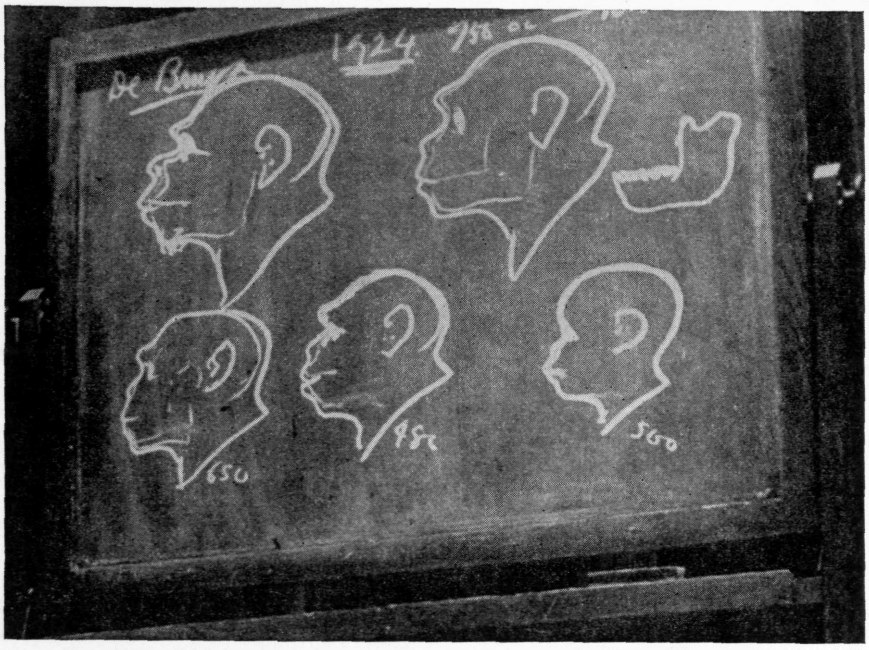
the same time, or were some of them separated by hundreds of thousands of years? Does a study of the setting in which their remains occur suggest anything as to their nature, habits and environment, which a careful study of fossil material on a laboratory table would not reveal? These are the questions the anthropologist asks the geologist and the paleontologist.

But first let us approach the anthropologist. Unfortunately we seem to find him sitting on the fence—though maybe less assured than he was when Dart faced the scientific world almost single-handed with his back to the wall and his "baby" on his arm. Of course, the anthropologist speaks with dogmatic assurance or he wouldn't be a scientist! But maybe I do him an injustice. Perhaps it is he who is putting the australopiths on the fence for our inspection. And having hardly more knowledge about these matters than had Australopithecus himself, I can only quote what comes out of wiser heads than mine.

Dr. Weidenreich, to whom we owe the later precise studies of *Sinanthropus pekingensis*, was in no two minds about *Australopithecus*. In a paper written in 1948 for the volume commemorating Dr. Broom's eightieth year, he admits the human appearance of the dentition and other features but considers that the shape of the brain is simian, and concludes that the puzzling humanlike features these creatures show were holdovers from the past, rather than anticipations of the future. "In other words, the features they share with man are those retained from an original stock when they, like typical anthropoids, acquired special differentiation. These led them away from the hominids whose differentiations

went in other directions" (12). When I spoke with Dr. Weidenreich in New York a few days before his death last July, he said he had seen nothing to change this opinion.

Professor LeGros Clark of Oxford, dean of British anatomists, takes a less extreme position. In New York last June he stated his opinion (i) that the ten skulls of which parts had then been found are all of animals belonging to the same group, (ii) that they show certain features which distinguish them from typical apes (*e.g.*, the absence of the gap next the incisor teeth which characterizes the latter), (iii) that their original owners were ape-like creatures with some hominid features that are closer to man than to apes, and (iv) that there is nothing in their morphology that would prevent their being ancestral to *Homo sapiens* (13). Others who, at first cautious, are now ready to accept *Australopithecus* as already human include Adloff, Kleinschmidt, Sollas and Von Koenigswald.



Homo neanderthalensis *Pithecanthropus erectus*
Paranthropus robustus *Plesianthropus transvaalensis* *Australopithecus africanus*

PLATE IV. Blackboard sketches made by Dr. Robert Broom at American Museum of Natural History of cranial outlines and facial reconstructions of Australopithecine and higher hominid types.

Reference was made to the human appearance of the pelvic bone found by Broom at Sterkfontein. I saw it lying on his table between the corresponding bones of a chimpanzee and a modern Zulu woman (6). The resemblance to the latter, and the entirely different proportions of its chimpanzee counterpart, were so glaringly obvious as to be beyond dispute. The later finds at Makapansgat led Dart to break up and examine carefully every block of breccia and fragment of bone in the ten tons that had come to the laboratory from the 600 tons on the cave dump—a long task, not yet completed. He thus recovered odd teeth, bits of limb bones, a left ilium and a right ischium, which fully confirm the evidence of the Sterkfontein pelvis by proving even more human-like (14). But although these features strengthen the apparent close relationship to modern man, direct descent is another matter. For since man was certainly living on the earth by very early in the Pleistocene Period, the australopiths can be the progenitors of

modern man only if the Sterkfontein fossils date from the Pliocene Period, unless, indeed, more than one race of men evolved independently in different centres. Hence the need to fix the geological age of the breccias on some other basis.

Australopithecus himself then, lying silent on the laboratory table beside the other primate skulls, refuses, sphinx-like, to answer the question, and winks at the geologist, who goes discreetly back to his cave to look for clues of other kinds. The cave-deposits yield fossil bones of quite a range of other animals. If these can be shown to have lived at the same time as Australopithecus, and if their geological age is exactly known, the deposit may be dated. Failing these, the character of the cave-filling itself might be linked to climatic changes related to such widespread fluctuations as those which went with the onset and waning of the glacial stages of the Great Ice Age. Yet again, the opening up and subsequent filling of the caverns is related to landscape changes—especially those con-

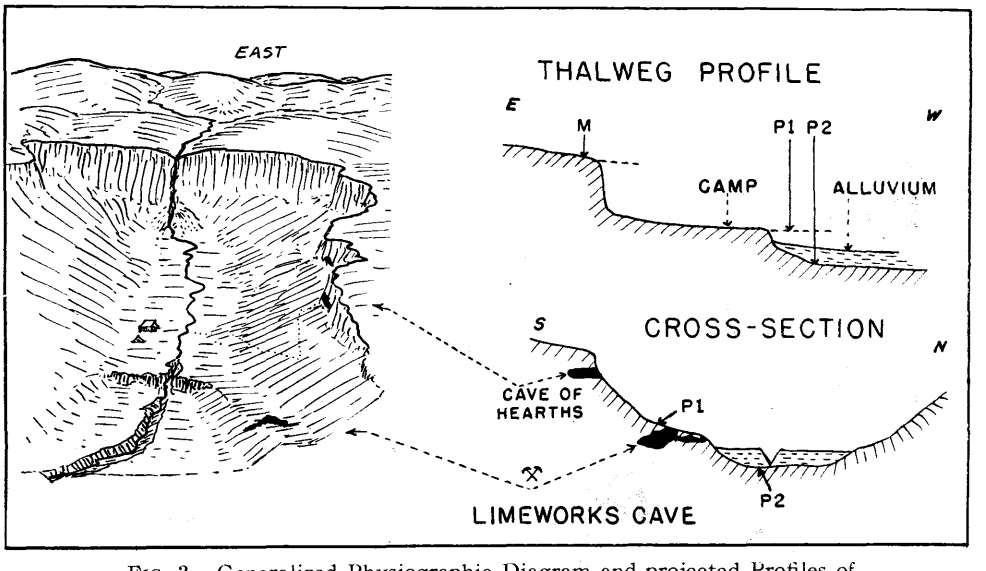


FIG. 3. Generalized Physiographic Diagram and projected Profiles of Makapansgat Valley.
Showing position of Limeworks and Cave of Hearths relative to erosion surfaces M, P1 and P2.

nected with the past history of the rivers, the widening of the valley floors, and the wearing back of the hill slopes. If no single approach gives a certain answer, several may combine to set limits to the antiquity of the creatures embedded in the cave-filling.

The geological age of the fossil-bearing deposits may first be fixed within broad limits and thus clamped, as in the jaws of a vise, between an earlier and a later date. As the gap is narrowed, the dating becomes more precise. Since neither the creatures nor their fragile remains could get into a fissure or cave before it was opened to the air, they cannot have roamed the land till *after* the limestone was first exposed by erosion. But this occurred well before the close of the Tertiary Era, which leaves the lower limit sadly loose and far-extended. In the other direction, the bedrock and its cave fillings had been bevelled off to a smooth surface by erosion *before* the streams gained enough fresh energy to incise it again. Therefore the cave fillings were already there at least before the penultimate life cycle of the streams. Fig. 3 shows the sharply discordant relationship between the steep slopes of the Makapansgat valley and the older low-relief surface of the upland it incises. The bench bevelling the Limeworks breccia is a remnant of the

P-1 surface which is preserved in the valley head. Downstream from the camp-site knickpoint, this surface has been almost entirely destroyed by a later erosion cycle (P-2). Since then, the rock-floor of the valley has been buried under a ten-foot cover of alluvium and surface wash, and is only exposed where cut through by recent stream action. (Somewhat comparable features may be seen in many of the valleys of southern Ohio, where branches and terraces along the base of the hills provide strips of flat ground, much appreciated by railroad engineers and road builders since they stand well above flood-level when the fields on the valley bottoms go under water. But these farm-studded platforms are built of sand and gravel, hastily dropped by glacial meltwater, whereas the occasional tell-tale benches of South Africa had to be sculptured over a much longer time from solid rock.) On grounds which range farther afield than we can roam tonight, the final shaping of that lost landscape (P-1) at Makapan can hardly be much younger than Lower Pleistocene.[3] Consequently, the cave-fillings must be of greater age.

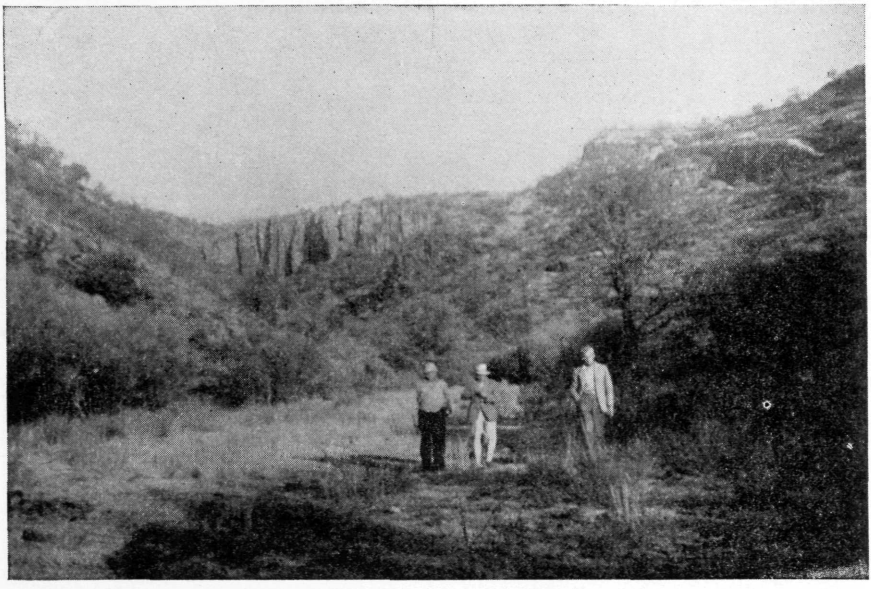


PLATE V. Camp, Dart and Haughton, in Makapansgat Valley.

Even this still leaves the time gap unhappily wide. Further field studies will undoubtedly cut it down.

Meanwhile the cave-deposits themselves throw further light on the problem. Whereas with surface sediment dropped by rivers the top layer is more recent than what lies below, any visitor to Mammoth Cave finds a whole network of galleries at different levels, connected by vertical chimneys or sloping chutes. A fissure extending to the surface may fill with debris, funneled down from above almost as soon as it is breached. A roofed cavern may fill more slowly, partly with

[3]Several factors conspire to make close dating of the Pre-Pleistocene erosional surfaces in South Africa peculiarly difficult. Almost the only Tertiary datum-level of any extent is that set by the Alexandria Limestone and its equivalents along the south-east coast, which have a marine fauna allied to that of Miocene-Pliocene age in Europe. Surfaces related to this and other Tertiary raised beach levels are hard to trace, (1) because prolonged uninterrupted denudation has destroyed the older landforms over wide areas, (2) because profiles run into the interior have to be carried over immense distances over varied structures which make the use of knickpoints and kindred tell-tale features unreliable as criteria of rejuvenation, and (3) because the attention to development of natural resources has left little margin of time and energy for geomorphic studies on the part of the competent but small group of qualified geologists available in so vast a region.

stalagmites and wall coatings left by evaporating limewater dripping from the ceiling, partly with sand and silt washed in by underground streams, and partly with fallen roof rock. As the roof collapses, both floor and ceiling are raised, and the cavity migrates upwards. Once filled, a cave site may be partially reopened by solution and even refilled a second time. Thus two caves in a single locality may have quite different histories. In Locality 1 at the Peking Man site, the infilled material was over 180 feet in depth and represented three distinct epochs of accumulation. One zone 25 feet deep formed an indivisible unit, all deposited in a brief space of time. Another just above it, only 17 feet thick, had 100 separate layers,—black, red and yellow from the hearth-fires of repeated human occupation. Caves and their contents are therefore capricious things, often guilty of deceitful underground behavior which may mislead the unwary.

Unlike the other Australopithecine sites, the classic Taungs locality was not a cave. The fossils occur in a pink breccia of rock fragments choking fissures in an immense platform of travertine. This platform was built out in irregular sheafs of fluted curtains, festoons and cauliflower-like growths, round the outlets of long-dead springs in a notch of a Transvaal dolomite escarpment at the edge of the Kaap Plateau (Plate I). Animals that came to drink and lost their footing, or died on the slopes above, were washed into open crevasses and pockets, along with sand, gravel, and coarser rock debris. In time, the spreading growth of travertine had advanced 1200 feet from its earliest position. Enough accumulated to keep the battery of Norlim lime-kilns running full blast for two decades. Hence its period of growth must have spanned some tens of thousands of years. The individual breccia-pockets are sometimes roughly layered but, except that the lower rear parts of the deposit are older than the front upper parts, the structure offers little on which to base a stratigraphic sequence. However, its upper surface is pitted with solution pockets choked with red-brown earth, obviously dating from a later epoch of different conditions. This brown earth is criss-crossed with white veins of calcite, and sometimes contains late Paleolithic stone implements and even layers of ash, charcoal, and burnt bones. Right on the surface we picked up dozens of small stone flakes, identified by Dr. van Riet Lowe as belonging to the Smithfield and Wilton microlithic cultures, corresponding to Aurignacian and Magdalenian types of the later Old Stone Age of Europe.

Six months of excavation (1947–1948) by the University of California Expedition at some 30 sites along the edge of the Kaap plateau on either side of Taungs produced no new australopithecine material but had other results of importance. In many places the pink breccias yielded fossils of his contemporaries, including baboon skulls of types found at Sterkfontein and Makapan. And at a number of sites, beneath the pink breccia, Dr. Camp's party found an older grey breccia, with remains of horse and antelope, invariably *sans* baboons (15). Along the face of the escarpment there are open caves of still younger date, some with Middle Stone Age implements sealed in the floor where Man dropped them, others with even more recent artifacts showing Bushman techniques. But until the fossils from the two breccias have been studied and compared with those from other sites, we can say only that as far as Taungs is concerned the pink Australopithecus-breccia is distinctly *younger* than the moister days with horse and antelope of the gray breccia, and considerably *older* than the brown earth pockets of late Pleistocene days when human culture had already advanced through several stages.

In the Krugersdorp district and at Makapan we are dealing not with surface crevasses and pockets in spring deposits, but with true cavities in bedrock. The rock at the Sterkfontein, Kromdraai and Bolts Farm sites is Transvaal Dolomite, essentially the same formation as at Taungs. At Sterkfontein, the caves follow two main fissure systems which run north down the dip of the strata. In the spot where *Plesianthropus* was first found, the character and position of the material now occupying what once was a cave argue against its having been used as a lair by animals. The filling is mainly of boulders and rock fragments of all sizes in a

matrix of terracotta sand, well cemented with lime. Much of the rock debris had been weathered above ground level before falling into the hole along with blocks of roof-rock. No stratification can be detected, though the lower part of the mass is on the whole coarser and freer from fossils, while broken bones become increasingly abundant in the upper, finer portion of the breccia. This distinction between a lower and an upper zone is seldom abrupt, but follows an inclined surface, as if the whole mass involved successive slumping on the side of a heap or talus. It is probable, therefore, that, except for rodents, bats, and other small cave-dwellers, the fossil material, like the bulk of the deposit, was funneled down from the surface.

For caves to form, moisture is necessary. But climates fluctuate. In places, the breccia is separated from the bedrock by a pavement or wall-coating of travertine. Further, according to Cooke (16), the sandy matrix of the breccia has much less chert and quartz in proportion to carbonate than exists in the soil on the hill slopes today. This suggests that the climate when the cave was filling

PLATE VI. Dolomite caves in Makapansgat Valley.

was *drier* than that of today, thus leaving a greater percentage of dolomite unleached in the soil than occurs under present conditions.

This is the same sequence of climatic fluctuations as was noted at Taungs, where the formation of the pink breccias was both preceded and followed by conditions of greater moisture. Haughton has pointed out that the observed facts call only for (a) a moist period to account for cave and fissure solution, (b) a semi-arid epoch to explain the angular dolomite fragments with weathered crusts, and the red sandy matrix, (c) a period of renewed moisture to cement these into travertine, and (d) the period of renewed erosion which bevelled the bedrock and incised the valley of the Vaal and its tributaries (17). (This generalization refers to the climatic fluctuations during the critical interval between formation of the cavities and the time when the fossiliferous breccia choking them suffered the same surface reduction that affected the entire region. Haughton was concerned neither with the earlier erosional stages which first exposed the limestone, nor with the clearly marked episodes which punctured the later history of the drainage system of the area.)

It would of course be highly significant if the inferred sequence of climatic

fluctuations could be shown to tally with more widespread changes such as those which caused the successive advances and retreats of the Pleistocene ice-front in Europe. Though East Africa has several volcanic peaks within a degree of the Equator with active glaciers on their flanks today, there was no Great Ice Age in South Africa. But the arid stage in the wet-dry-wet sequence must have swept an increased volume of sand and loess into the lee sector. Bosazza believes he can identify four distinct invasions of desert conditions during and since the Pliocene, one of these being attested by a mantle of red sand and loess along the Harts near Taungs (18). But though the stages of Alpine ice advance have been correlated with climatic and sea-level changes recorded well outside the glaciated areas on both sides of the Mediterranean, we still know too little as to just how closely these tally with events further from the ice centers. One might argue that each epoch of renewed erosion in, say, the Kharga Oasis of Egypt meant heavier rainfall; and that these correspond exactly with the times when, in more northerly latitudes, increased precipitation brought the snow which became the ice. But the

PLATE VII. Excavation at Sterkfontein site.

climatic controls governing the spread of ice conditions are still too poorly understood for it to be safe to equate pluvial conditions in Kenya with glacial stages in the Alps, still less to link the spread of the Kalahari desert with inter-pluvial or interglacial stages on the other side of the Equator.

The growth of the Pleistocene ice-caps withdrew from the ocean enough cubic miles of water to lower sea-level on every coast around the globe. With each such marine retreat, rivers had to entrench their channels, first at their mouths, and then progressively upstream. But shifts of standline may result also from purely local disturbances of the Earth's crust. And until these have been ruled out as a possible cause, we dare not assume that any particular ancient sea-beach, standing today at, say, 600 feet above sea-level, records the highwater mark of a particular interglacial stage. Correlation is made harder by the fact that in any case most of the older beaches have been warped from their pristine horizontal position. The S. E. coast of Africa has excellent raised beach lines and progress is being made in unravelling these frayed edges of the record. But as yet it has not been extended back to the time when Australopithecus was alive.

So thus far neither inferred fluctuations of climate, nor sea-level shifts traced by knickpoints up the rivers, give criteria of the definiteness needed to fix the particular geological dates in question.

There remains the paleontologist's line of attack—that of correlating animal fossils found in the australopithecine breccias with their dated equivalents elsewhere. The faunal assemblages at the Taungs, Makapan and Krugersdorp sites all belong to the same general epoch of geological history. But like the slightly younger Peking Man fauna, they occur in an isolated region, far from the nearest place where precise age-determinations have been possible. Furthermore, the assemblages at the various sites show differences greater than can be explained by immediate environment or mere chance. It is clear, as might be expected, that they are not strictly contemporaneous, and represent a span of time measurable perhaps in thousands of years, if not more. Thus Sterkfontein has yielded—to mention only a few types by their common names—sabre-tooth tiger, roan antelope,

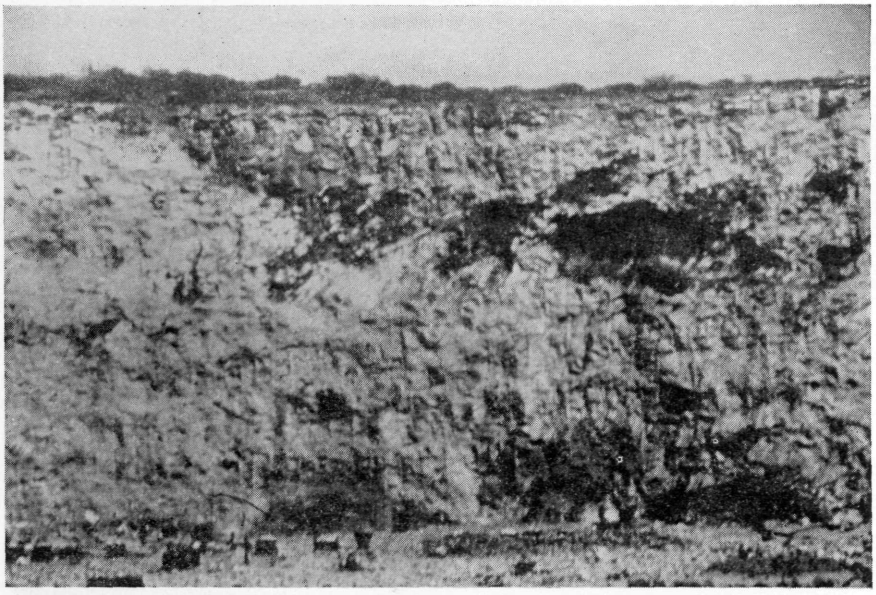


PLATE VIII. Quarry face at Norlim Limeworks, showing dark pockets of fossiliferous breccia.

reed-buck, wildebeest, a small jackal, several species of baboon, golden mole, elephant-shrew, rats and other rodents. Bolts Farm produced a host of mammals, including the same shrew as at Sterkfontein, but a larger golden mole, a different sabre-tooth, besides fossil pig, a single elephant tooth which may prove significant, and other types not as yet found elsewhere. Kromdraai on the other hand has some of the same animals, but lacks both sabre-tooth and pig, while its baboons are of a different species from those at Sterkfontein. On this account, Broom considers *Paranthropus* from Kromdraai to be geologically slightly younger than *Plesianthropus*. From Makapan, Dart reports two species of baboon found also at Sterkfontain, lion, hyena and jackal, two extinct pigs, rhinoceros, hippopotamus, two extinct relatives of the giraffe, and fourteen types of *Bovidae*, eight of them new to science. None of the Taungs creatures were forest dwellers, several being definitely desert forms. Both Makapan and Taungs have types not found at Sterkfontein or Bolts Farm, but there is enough in common for the four sites to be regarded as of approximately the same geologic age. The assemblage as a whole shows affinities with the Villafranchian fauna of Northern Italy.

A single discrepant element is the presence at Sterkfontein of *Lycyaena silberbergi*, a hyena-like animal closely resembling one found in the Lower Pliocene of Europe and Asia. Until further study has established a more certain affinity, it is unwise to place too much weight on this single animal, which may, after all, have lived on in Africa long after his European and Asiatic cousins had become extinct.

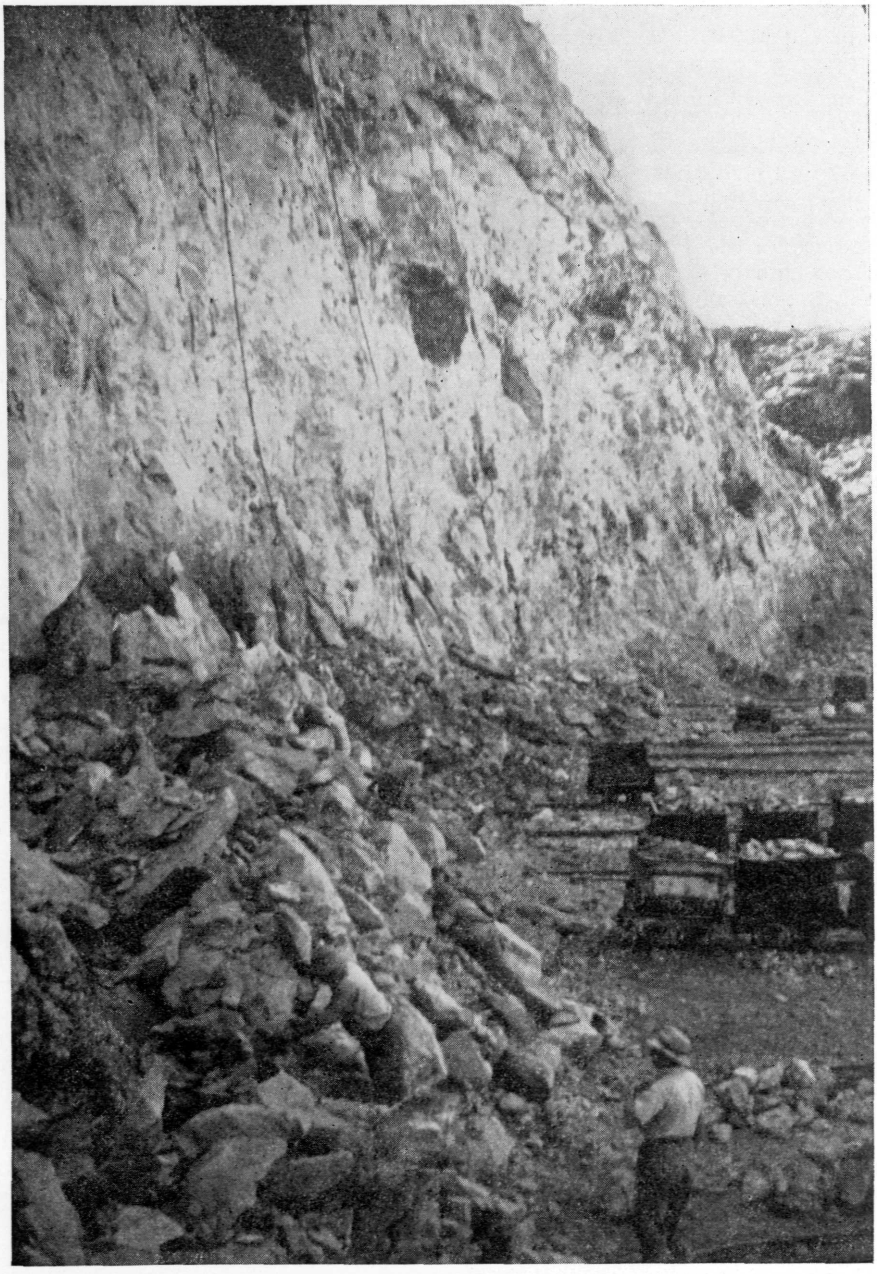


PLATE IX. Fossil hunting in blasted rocks at Taungs site.

Stratigraphic opinion is divided as to the exact place of the Villafranchian with respect to the Plio-Pleistocene boundary,—depending on whether the latter is to be set by the first symptoms, the main onset or the approach to culmination of the first glacial advance, the shift of sea-level, or the resulting changes in fauna, marine or terrestrial. The question was thought worthy of a special section in the XVIII International Geological Congress last summer in London, where a mass of evidence was presented in favor of various period-markers. Some authorities have placed both the Villafranchian and the succeeding Calabrian epochs in the Pleistocene. Others would have the boundary separate the two. As far as the Eastern Hemisphere is concerned, the most satisfactory solution is that of Gignoux which leaves both in the Pliocene, a conclusion supported by Pilgrim (19) on the basis of faunal assemblages in Europe and Asia. Zeuner (20) has attempted to correlate the arguments from this and other lines of evidence. Using the latest data of Milankovitch (21) on climatic fluctuations, he places the lower boundary of the Pleistocene 600,000 years ago. American geologists favor a somewhat earlier date for the dawn of the Great Ice Age on this continent. And yet, maybe the exact hour of dawn is more a matter of local point of view than a source of concern to Australopithecus himself, for on any reckoning, he seems to have been living a full million years ago.

We have looked at our extinct friends from a wide variety of angles—namely, those of the anatomist, anthropologist, geologist, physiographer, stratigrapher and paleontologist, and perhaps are left with the feeling that nothing has been achieved except to shed a flood of inspissated darkness on a cloud of confusing uncertainties. Yet the evidence from these various lines of approach seems to be closing in on the figure of a primitive human, barely emerging from his anthropoid background, who stepped out from the shadows into the sun on the South African veld about the time when the ice sheets were starting to push down across Canada and Northern Europe. Each new piece of evidence from whatever source has to be fitted into the new jigsaw puzzle. Thus *Australopithecus prometheus* was given his second name because microscopic and chemical study of apparently burnt animal bones strongly suggested the use of fire—as proved the case with Peking Man. Some have criticized Dart for leaving out the question-mark he originally placed before the word "(?) Promethean" (11). What matter a few specks of carbon black? And yet, one other curious feature was noted by Dart (22) long before the recent discoveries. A high proportion of the fossil baboon skulls had been crushed in, as if by a severe blow, carefully aimed from the front. Admittedly an occasional ape might have walked in a cave exactly where a piece of roof-rock was about to fall on his cranium. But it was hard to account for the number of cracked skulls assembled on Dart's laboratory table from different localities, several with the same peculiar double-dent trade mark, as if struck with the leg-bone of an ox or some other large animal. It seemed no easier when Dr. Peabody found the same condition in half a dozen more baboon skulls unearthed at Taungs. Careful study showed that 42 out of 58 crania of *Parapapio* from the three *Australopithecus* sites showed the same feature. The blows struck were deliberate and meant to kill. Furthermore, the blows not aimed straight from the front were preponderantly struck at the left side of the head, as if by a right-handed individual! (25). Granted a verdict, not of "death by misadventure," but of "baboonicide," there is of course the question that was raised in the parallel case of "Humanity v. Peking Man"—Is it possible that Australopithecus, like Sinanthropus, could try to plead "Not guilty," by blaming some other higher primate who shaped the crude stone tools we found in the cave at Choukoutien, but who was clever enough to hide his own skeleton? All one can say is that as yet there is no evidence pointing in that direction, even Swartkrans Man being an Australopithecine himself.

The fractured adolescent mandible from Makapansgat (23) corroborated previous evidence (24) that the Australopithecinae not only were carnivorous hunters of large and small game, but were cannibalistic and killed one another with stones, wooden clubs or bone bludgeons. An account of lethal injuries inflicted upon the crania of baboons found at Taungs, Sterkfontein and Makapansgat has recently been published by Dart (25). A letter just received from him adds that the Makapan breccia has now also yielded evidence of a bone and horn culture, little, if at all, different from that which l'Abbe H. Breuil claimed as characteristic of Peking Man.

Presidential addresses possess one great advantage, alike for the pride of the perpetrator and for the comfort of his long-suffering audience—for, like the motion to adjourn, they are not debatable.

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